

## REFRIGERANT CHANGEOVER FROM HFC R134a TO HFC/HFO R450A & R513A



### WARNING

Use only Emerson Climate Technologies approved refrigerants and lubricants in the manner prescribed by Emerson Climate Technologies. Other refrigerants and lubricants may, in some circumstances, be dangerous and could cause fires, explosions or electrical shorting. Contact Emerson Application Engineering for more information.

The refrigerants referred to in this document are safe to use when handled properly. Any refrigerant can cause injury or even death when mishandled. Please review the guidelines carefully and consult the product safety data sheet provided by the refrigerant manufacturer.

This retrofit guideline is applicable to Copeland™ brand compressors in high or medium evaporation temperature applications, which have been approved for R450A or R513A.



### WARNING

#### **Use of R450A and R513A refrigerants! Risk of compressor damage!**

Refrigerant migration of R450A or R513A into the compressor crankcase could cause low oil viscosity, which could lead to compressor damages. When using R450A or R513A it is critical to meet the following requirements:

- maintain adequate superheat settings with a minimum superheat of 8-10K;
- no liquid refrigerant migration into the compressor at any time, especially during standstill, during or after defrost, or after reverse mode for example in heat pumps;
- pump-down is recommended;
- the use of a crankcase heater is mandatory;
- retrofit to R450A and R513A is only allowed for compressors which have been officially approved for these refrigerants.

Contact your local Application Engineering representative for any further information.

## 1 Considerations when retrofitting

- 1) **R450A or R513A should not be mixed with any other refrigerant!** These refrigerants should neither be mixed with air to check for system leaks. Open flames in the presence of any fluorocarbon refrigerant can decompose the refrigerant and form hazardous acidic compounds. Use electronic leak detectors designed for use with R450A and R513A.
- 2) Do not work in high concentrations of refrigerant vapours. Always maintain adequate ventilation in the work area. After any leak, ventilate the area well before attempting to repair an equipment.
- 3) Polyolester lubricant in use with R134a is also suitable for use with R450A or R513A. There is no need for a determined oil change, unless there are questions about the lubricant, or if tests indicate it is contaminated or has a high acid number. Approved lubricants for Copeland brand compressors are Emkarate RL32 3MAF and Mobil Arctic EAL 22CC.
- 4) In accordance with EN 378, R450A and R513A fall under the same refrigerant safety group A1 (no flame propagation, not toxic) as R134a. Therefore, a field retrofit with the same system safety concept and safety components is generally possible.
- 5) The system capacity and efficiency can be somewhat different with R450A or R513A from what they are with R134a. For medium temperature conditions, R450A shows approximately 87% capacity with similar efficiency

compared to R134a. One must check if the remaining system capacity would be sufficient. R513A shows similar capacities and efficiencies compared to R134a.

In most multiple compressor racks, there should still be adequate capacity. However, it is recommended that system capacity verification be done using Copeland brand products Select software or the comparison factors published by the refrigerant manufacturer.

| Refrigerant | Characteristics |           | Medium temperature |              |
|-------------|-----------------|-----------|--------------------|--------------|
|             | GWP*            | Glide (K) | Capacity**         | Efficiency** |
| R134a       | 1300            | 0.0       | 100%               | 100%         |
| R450A       | 547             | 0.8       | 87%                | 103%         |
| R513A       | 573             | 0.0       | 104%               | 99%          |

\* GWP according to the 5<sup>th</sup> IPCC review

\*\* Capacity and efficiency figures according to refrigerant manufacturers published comparison factors

**Table 1: Capacity, efficiency and characteristics comparison**

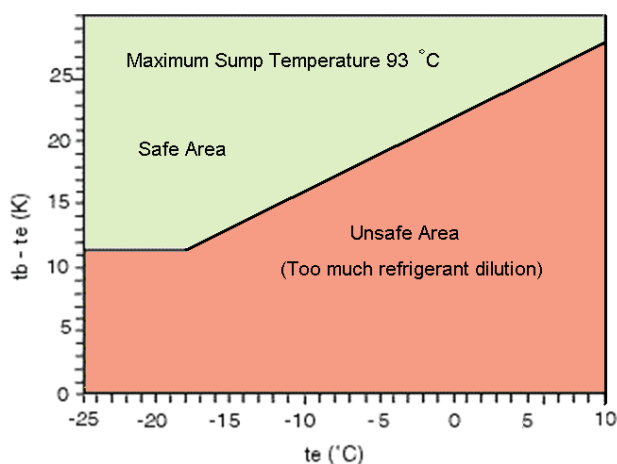
- 6) In retrofitting an existing refrigeration system, material compatibility and the condition of the existing seals and gaskets must be taken into account. Heat set, compression set and seal shrinkage can affect the condition of an existing seal or gasket. When the system is put under vacuum, the sealing device can be displaced, creating the potential for leakage. A general gasket change is usually not required, unless some specific gaskets show noticeable damages and need to be changed.
- 7) Special attention should be paid to the refrigerant characteristics of R450A and R513A in the liquid phase and to the relationship with the ester oil. Refrigerant migration into the compressor crankcase could cause low oil viscosity, which could lead to compressor damage.

High priority should be given to the observation of the system for possible liquid refrigerant migration into the compressor. The system behaviour should be checked at standard operation, during standstill and especially during or after defrost, or after reverse mode for example in heat pumps. All necessary precautions must be taken to prevent liquid refrigerant migration into the compressor, for example:

- the superheat settings of the expansion device should be adjusted for a minimum superheat of 8-10K;
  - the installation of a crankcase heater is mandatory;
  - the system operation should work with a "pump-down scenario";
  - use of suction accumulators, unless it has been qualified that an accumulator is not needed.
- 8) Discharge temperatures of R450A and R513A are similar or marginally lower (1-5%) in comparison with R134a. This could result in slightly larger operation envelopes. Please refer to the individual technical data, for example in the Copeland brand products Select software.
  - 9) R450A and R513A have other density and mass flow than R134a. It is recommended that pipe sizing be checked to determine that pressure drops and velocities would be acceptable with the new refrigerant. Checking pipe sizing will confirm that capacity and efficient oil return are not being negatively affected.
  - 10) Both refrigerants R450A and R513A are blends of R134a (HFC) and R1234yf/ze (HFO). The composition of R450A is 58% R1234ze and 42% R134a. R450A is a zeotropic blend and has temperature glide of 0.8 K. R513A consists of 56% R1234yf and 44% R134a, it is an azeotropic blend with no temperature glide.
  - 11) For blend refrigerants like R450A and R513A, pressure/temperature data will include bubble and dew point data. To determine superheat, the dew temperature column in the temperature/pressure table has to be used. To determine subcooling, the bubble temperature column has to be used. The average condensing temperature is the mean of the dew and bubble temperatures at the condensing pressure. The average evaporating temperature is the mean of the temperature at the evaporator inlet and the dew temperature at the evaporating pressure.
  - 12) It is essential that blend refrigerants like R450A or R513A be liquid-charged removing only liquid from the filling cylinder. Vapour-charging may shift the refrigerant composition and could result in damage to the system. To prevent compressor damage, it is advocated not to charge liquid into the suction line.

Due to other liquid density and weight of R450A and R513A, the refrigerant charge can be different from the initial charge for R134a.

- 13) Compressor suction and discharge pressures for R450A and R513A differ from those for R134a. It may be necessary to reset the pressure cut-outs to suit the different pressures of the replacement refrigerant. This procedure should be done carefully to avoid exceeding the recommended operating limits of the compressor. Pressure regulators may have to be reset. Contact the manufacturer for correct settings.
- 14) Systems that use a low-pressure controller to maintain space temperature may need to have the cut-in and cut-out points changed and need adjustment.
- 15) Many refrigeration system controls, eg, supermarket control systems, rely on the pressure-temperature relationship of the refrigerant in use. When retrofitting from R134a to R450A or R513A, the control settings have to be adjusted with the new refrigerant settings. Please refer to control system manufacturer for guidance.
- 16) R450A and R513A have other mass flow rates than R134a (R513A has higher and R450A has lower mass flow rates in comparison with R134a), but should normally stay within the usable range of a properly sized and installed R134a expansion device. For R450A installations, please check if the original expansion valve (or valve orifice) has the required capacity. If not, the expansion valve (or valve orifice) must be changed. For all R450A and R513A expansion devices it is required to adjust the valve superheat settings. Use a PT-chart (dew point, saturated vapour values) for correct measurements and superheat adjustments. Consult the expansion valve manufacturer for correct selection and superheat settings.
- 17) For R450A and R513A refrigerants Emerson recommends to use suction accumulators, unless it has been qualified that an accumulator is not needed. To determine if the accumulator can be removed, dedicated tests must be carried out to ensure that excessive liquid does not flood back to the compressor. All possible operating conditions, especially the conditions which could differ from the standard operation, like defrost, bypass, reverse operation, varying loads and so on, must be tested. Excessive flood back occurs when the sump temperature drops below the safe operation line shown in the following chart:



**Figure 1: Dilution chart for transient operation (tb = bottom shell temp.; te = evaporating dew temp.)**

- 18) Filter-driers must be changed at the time of conversion. They should have an equilibrium point of dryness (EPD) of 50 ppm or lower.
  - Solid core driers such as Emerson Climate Technologies ADK are compatible with R450A or R513A.
  - Compacted bead type driers Alco FDB and filter drier shell types Alco ADK Plus and Alco FDS Quick Cap are also compatible.
  - Loose fill type driers are not recommended and should be replaced with the types referenced above.

## 2 Changeover procedure

Before starting the changeover, at least the following items should be readily available:

- Safety glasses
- Gloves
- Refrigerant service gauges
- Electronic thermometer
- Vacuum pump capable of pulling 0.3 mbar
- Electronic leak detector, suitable for R450A or R513A

- Refrigerant recovery unit including refrigerant cylinder
  - Proper container for removed lubricant
  - Replacement liquid line filter-drier(s)
  - Crankcase heater, if not installed
  - Refrigerant accumulator, if needed
  - New POE lubricant, if needed
  - R450A/R513A pressure temperature chart
  - R450A/R513A refrigerant
- 1) Check the system for possible liquid refrigerant migration into the compressor. Observe the system behaviour in standard operation, during standstill and especially during or after defrost, or after reverse mode. Take all necessary precautions to prevent liquid refrigerant migration into the compressor.
  - 2) Check if a crankcase heater is installed and if the on/off settings are appropriate. Ideally, the crankcase heater is always switched on during all compressor off periods. Otherwise the crankcase heater must be turned on 12 hours before each compressor start after longer standstill periods.
  - 3) To determine if an accumulator is needed, dedicated tests during different operating conditions must be carried out.
  - 4) Record baseline data on original R134a system performance with the system operating under stable conditions. The following data should be recorded as a minimum with R134a still in the system: compressor inlet and outlet pressures and temperatures, outdoor temperature and liquid temperature, preferably near the expansion valve inlet. This will enable superheat, subcooling and pressure ratio to be determined and provide the base data for comparison when the system is put back into operation with the R450A or R513A.
  - 5) Disconnect electrical power to the system.
  - 6) Properly remove the R134a from the system. The refrigerant charge should be isolated from the system by pumping it down into the receiver enabling the bulk of the charge to be quickly transferred to the recovery cylinder. In all cases the refrigerant must be removed from the system using a recovery machine capable of meeting or exceeding the required levels of evacuation. The charge must be collected in a recovery cylinder. Do not vent the refrigerant. Measure and note the amount removed. Knowing the recommended R134a refrigerant charge size for the system is helpful. In all cases weigh the entire amount of removed refrigerant. This amount can be used as a guide for the internal quantity of the R450A or R513A refrigerant to be charged to the system.
  - 7) Replace the liquid line filter-drier with one that is compatible with R450A or R513A.
  - 8) Install a crankcase heater, if not present yet.
  - 9) Install a liquid accumulator in the suction line, if needed.
  - 10) If the polyolester oil is contaminated or an acid test indicates high levels of acidity, then a lubricant change is required. If affected, drain the existing lubricant from the compressors, separators and oil reservoirs. Measure the amount (volume) of lubricant removed. Change lubricant filters if present. Recharge the system with polyolester lubricant, use the same amount (volume) as was removed.
  - 11) Check if the existing expansion devices (or valve orifices) would have enough capacity when operated with R450A or R513A. If needed, change the expansion device or valve orifice. In any case, it is required to adjust the expansion valve in order to reset the superheat settings for R450A or R513A. Maintain adequate superheat settings of minimum 8-10K. Consult the valve manufacturer for guidance and recommendations.
  - 12) Evacuate the system to 0.3 mbar. A vacuum decay test is suggested to ensure that the system is dry and leak free. Apply normal service practices to reconnect and evacuate the system. To remove air and other non-condensables, it is recommended to evacuate the system from both sides. Attempting to evacuate a system with the pump connected only to the low-side of the system will not adequately remove moisture and non-condensables such as air. Use a good electronic gauge to measure the vacuum. An accurate reading cannot be made with a refrigeration gauge.
  - 13) Check the system for leaks applying normal service practices.
  - 14) Recharge the system with R450A or R513A. Remove only liquid from the charging cylinder. The first charge should be approximately 85% of the R134a charge by weight. Record the amount of refrigerant charged.

- 15) Check system operation and operating controls. Update control settings for the operation with R450A or R513A. Start the system and allow conditions to stabilize. The discharge pressure of R450A or R513A can be different from that of R404A and condenser fan and ambient controls may require adjustment.
- 16) Add the "pump-down" function to the system operation.
- 17) Adjust the refrigerant charge.
- 18) Operate the system. Record the data and compare to the data recorded at step 4.
- 19) Properly label the components. Tag the compressor with the refrigerant (R450A or R513A) and the lubricant used.



### CAUTION

**These guidelines are intended for use with R450A or R513A only.** Other refrigerants may not be compatible with the materials used in Copeland brand compressors or the lubricants recommended in this Technical Information.

The information contained herein is based on technical data and tests which are believed to be reliable, and is intended for use by persons having technical skill, at their own discretion and risk.

Since conditions of use are beyond the control of Emerson, no liability can be assumed for results obtained or damages incurred through the application of the information presented.

### 3 Pressure/Temperature table

| Pressure<br>[bar(g)] | R134a  |        | R450A  |        | R513A  |        |
|----------------------|--------|--------|--------|--------|--------|--------|
|                      | Dew    | Bubble | Dew    | Bubble | Dew    | Bubble |
| 0.00                 | -26.36 | -26.36 | -23.05 | -23.66 | -29.26 | -29.38 |
| 0.10                 | -24.26 | -24.26 | -20.89 | -21.51 | -27.14 | -27.25 |
| 0.20                 | -22.31 | -22.31 | -18.89 | -19.51 | -25.17 | -25.27 |
| 0.30                 | -20.48 | -20.48 | -17.01 | -17.64 | -23.33 | -23.42 |
| 0.40                 | -18.76 | -18.76 | -15.24 | -15.88 | -21.59 | -21.67 |
| 0.50                 | -17.13 | -17.13 | -13.57 | -14.21 | -19.94 | -20.02 |
| 0.60                 | -15.59 | -15.59 | -11.99 | -12.62 | -18.38 | -18.45 |
| 0.70                 | -14.12 | -14.12 | -10.48 | -11.11 | -16.89 | -16.96 |
| 0.80                 | -12.72 | -12.72 | -9.03  | -9.67  | -15.47 | -15.53 |
| 0.90                 | -11.37 | -11.37 | -7.65  | -8.29  | -14.11 | -14.17 |
| 1.00                 | -10.08 | -10.08 | -6.32  | -6.97  | -12.80 | -12.86 |
| 1.10                 | -8.84  | -8.84  | -5.05  | -5.69  | -11.54 | -11.59 |
| 1.20                 | -7.64  | -7.64  | -3.82  | -4.47  | -10.33 | -10.38 |
| 1.30                 | -6.49  | -6.49  | -2.63  | -3.28  | -9.16  | -9.20  |
| 1.40                 | -5.37  | -5.37  | -1.48  | -2.13  | -8.02  | -8.07  |
| 1.50                 | -4.29  | -4.29  | -0.37  | -1.02  | -6.93  | -6.97  |
| 1.60                 | -3.24  | -3.24  | 0.71   | 0.06   | -5.86  | -5.90  |
| 1.70                 | -2.22  | -2.22  | 1.75   | 1.10   | -4.83  | -4.87  |
| 1.80                 | -1.23  | -1.23  | 2.77   | 2.12   | -3.83  | -3.86  |
| 1.90                 | -0.27  | -0.27  | 3.76   | 3.11   | -2.85  | -2.89  |
| 2.00                 | 0.67   | 0.67   | 4.72   | 4.07   | -1.90  | -1.93  |
| 2.10                 | 1.58   | 1.58   | 5.66   | 5.01   | -0.97  | -1.00  |
| 2.20                 | 2.47   | 2.47   | 6.58   | 5.93   | -0.07  | -0.10  |
| 2.30                 | 3.34   | 3.34   | 7.48   | 6.82   | 0.81   | 0.79   |
| 2.40                 | 4.19   | 4.19   | 8.35   | 7.69   | 1.68   | 1.65   |



| Pressure<br>[bar(g)] | R134a |        | R450A |        | R513A |        |
|----------------------|-------|--------|-------|--------|-------|--------|
|                      | Dew   | Bubble | Dew   | Bubble | Dew   | Bubble |
| 2.50                 | 5.02  | 5.02   | 9.20  | 8.55   | 2.52  | 2.50   |
| 2.60                 | 5.83  | 5.83   | 10.04 | 9.38   | 3.34  | 3.32   |
| 2.70                 | 6.63  | 6.63   | 10.86 | 10.20  | 4.15  | 4.13   |
| 2.80                 | 7.41  | 7.41   | 11.66 | 11.01  | 4.94  | 4.92   |
| 2.90                 | 8.17  | 8.17   | 12.45 | 11.79  | 5.72  | 5.70   |
| 3.00                 | 8.92  | 8.92   | 13.22 | 12.56  | 6.48  | 6.46   |
| 3.20                 | 10.38 | 10.38  | 14.72 | 14.06  | 7.96  | 7.95   |
| 3.40                 | 11.79 | 11.79  | 16.16 | 15.51  | 9.39  | 9.37   |
| 3.60                 | 13.14 | 13.14  | 17.56 | 16.90  | 10.77 | 10.75  |
| 3.80                 | 14.46 | 14.46  | 18.91 | 18.25  | 12.10 | 12.09  |
| 4.00                 | 15.73 | 15.73  | 20.22 | 19.56  | 13.39 | 13.38  |
| 4.20                 | 16.96 | 16.96  | 21.49 | 20.83  | 14.65 | 14.64  |
| 4.40                 | 18.16 | 18.16  | 22.72 | 22.07  | 15.86 | 15.86  |
| 4.60                 | 19.33 | 19.33  | 23.92 | 23.27  | 17.05 | 17.04  |
| 4.80                 | 20.46 | 20.46  | 25.09 | 24.44  | 18.20 | 18.19  |
| 5.00                 | 21.57 | 21.57  | 26.23 | 25.57  | 19.32 | 19.32  |
| 5.20                 | 22.65 | 22.65  | 27.33 | 26.68  | 20.42 | 20.41  |
| 5.40                 | 23.70 | 23.70  | 28.42 | 27.77  | 21.48 | 21.48  |
| 5.60                 | 24.73 | 24.73  | 29.47 | 28.82  | 22.53 | 22.52  |
| 5.80                 | 25.73 | 25.73  | 30.50 | 29.86  | 23.55 | 23.54  |
| 6.00                 | 26.71 | 26.71  | 31.51 | 30.87  | 24.54 | 24.54  |
| 6.20                 | 27.67 | 27.67  | 32.50 | 31.86  | 25.52 | 25.52  |
| 6.40                 | 28.62 | 28.62  | 33.47 | 32.83  | 26.48 | 26.47  |
| 6.60                 | 29.54 | 29.54  | 34.42 | 33.78  | 27.41 | 27.41  |
| 6.80                 | 30.44 | 30.44  | 35.35 | 34.71  | 28.33 | 28.33  |
| 7.00                 | 31.33 | 31.33  | 36.26 | 35.62  | 29.23 | 29.23  |
| 7.20                 | 32.20 | 32.20  | 37.15 | 36.52  | 30.11 | 30.11  |
| 7.40                 | 33.06 | 33.06  | 38.03 | 37.40  | 30.98 | 30.98  |
| 7.60                 | 33.90 | 33.90  | 38.90 | 38.26  | 31.83 | 31.83  |
| 7.80                 | 34.72 | 34.72  | 39.74 | 39.11  | 32.67 | 32.67  |
| 8.00                 | 35.53 | 35.53  | 40.58 | 39.95  | 33.50 | 33.49  |
| 8.20                 | 36.33 | 36.33  | 41.40 | 40.77  | 34.30 | 34.30  |
| 8.40                 | 37.11 | 37.11  | 42.20 | 41.58  | 35.10 | 35.10  |
| 8.60                 | 37.89 | 37.89  | 42.99 | 42.37  | 35.89 | 35.88  |
| 8.80                 | 38.65 | 38.65  | 43.78 | 43.15  | 36.66 | 36.66  |
| 9.00                 | 39.40 | 39.40  | 44.54 | 43.92  | 37.42 | 37.42  |
| 9.20                 | 40.13 | 40.13  | 45.30 | 44.68  | 38.16 | 38.16  |
| 9.40                 | 40.86 | 40.86  | 46.05 | 45.43  | 38.90 | 38.90  |
| 9.60                 | 41.58 | 41.58  | 46.78 | 46.17  | 39.63 | 39.63  |
| 9.80                 | 42.28 | 42.28  | 47.51 | 46.90  | 40.35 | 40.35  |
| 10.00                | 42.98 | 42.98  | 48.22 | 47.61  | 41.05 | 41.05  |
| 10.50                | 44.68 | 44.68  | 49.97 | 49.37  | 42.78 | 42.78  |

| Pressure<br>[bar(g)] | R134a |        | R450A |        | R513A |        |
|----------------------|-------|--------|-------|--------|-------|--------|
|                      | Dew   | Bubble | Dew   | Bubble | Dew   | Bubble |
| 11.00                | 46.33 | 46.33  | 51.66 | 51.06  | 44.45 | 44.45  |
| 11.50                | 47.92 | 47.92  | 53.29 | 52.70  | 46.07 | 46.06  |
| 12.00                | 49.47 | 49.47  | 54.88 | 54.30  | 47.64 | 47.63  |
| 12.50                | 50.98 | 50.98  | 56.42 | 55.84  | 49.16 | 49.16  |
| 13.00                | 52.44 | 52.44  | 57.92 | 57.35  | 50.65 | 50.64  |
| 13.50                | 53.86 | 53.86  | 59.38 | 58.81  | 52.09 | 52.09  |
| 14.00                | 55.25 | 55.25  | 60.80 | 60.24  | 53.50 | 53.50  |
| 14.50                | 56.60 | 56.60  | 62.19 | 61.64  | 54.87 | 54.87  |
| 15.00                | 57.92 | 57.92  | 63.54 | 62.99  | 56.21 | 56.21  |
| 15.50                | 59.21 | 59.21  | 64.86 | 64.32  | 57.52 | 57.52  |
| 16.00                | 60.47 | 60.47  | 66.15 | 65.62  | 58.80 | 58.79  |
| 16.50                | 61.70 | 61.70  | 67.42 | 66.89  | 60.05 | 60.05  |
| 17.00                | 62.91 | 62.91  | 68.65 | 68.13  | 61.28 | 61.27  |
| 17.50                | 64.09 | 64.09  | 69.86 | 69.34  | 62.48 | 62.47  |
| 18.00                | 65.24 | 65.24  | 71.04 | 70.53  | 63.65 | 63.64  |
| 18.50                | 66.38 | 66.38  | 72.20 | 71.70  | 64.81 | 64.80  |
| 19.00                | 67.49 | 67.49  | 73.34 | 72.85  | 65.94 | 65.93  |
| 19.50                | 68.58 | 68.58  | 74.46 | 73.97  | 67.05 | 67.03  |
| 20.00                | 69.65 | 69.65  | 75.55 | 75.07  | 68.14 | 68.12  |
| 20.50                | 70.70 | 70.70  | 76.63 | 76.16  | 69.21 | 69.19  |
| 21.00                | 71.73 | 71.73  | 77.69 | 77.22  | 70.26 | 70.24  |
| 21.50                | 72.74 | 72.74  | 78.72 | 78.26  | 71.29 | 71.28  |
| 22.00                | 73.74 | 73.74  | 79.74 | 79.29  | 72.31 | 72.29  |
| 22.50                | 74.72 | 74.72  | 80.75 | 80.30  | 73.31 | 73.29  |
| 23.00                | 75.68 | 75.68  | 81.74 | 81.30  | 74.29 | 74.28  |
| 23.50                | 76.63 | 76.63  | 82.71 | 82.28  | 75.26 | 75.24  |
| 24.00                | 77.56 | 77.56  | 83.66 | 83.24  | 76.21 | 76.20  |
| 24.50                | 78.48 | 78.48  | 84.60 | 84.19  | 77.15 | 77.14  |
| 25.00                | 79.38 | 79.38  | 85.53 | 85.12  | 78.08 | 78.06  |
| 25.50                | 80.27 | 80.27  | 86.45 | 86.04  | 78.99 | 78.97  |
| 26.00                | 81.15 | 81.15  | 87.35 | 86.95  | 79.89 | 79.87  |
| 26.50                | 82.02 | 82.02  | 88.23 | 87.84  | 80.78 | 80.76  |
| 27.00                | 82.87 | 82.87  | 89.11 | 88.73  | 81.65 | 81.63  |
| 27.50                | 83.71 | 83.71  | 89.97 | 89.60  | 82.52 | 82.50  |
| 28.00                | 84.54 | 84.54  | 90.82 | 90.45  | 83.37 | 83.35  |
| 28.50                | 85.36 | 85.36  | 91.66 | 91.30  | 84.21 | 84.19  |
| 29.00                | 86.16 | 86.16  | 92.49 | 92.14  | 85.04 | 85.02  |
| 29.50                | 86.96 | 86.96  | 93.31 | 92.96  | 85.86 | 85.84  |
| 30.00                | 87.74 | 87.74  | 94.11 | 93.78  | 86.67 | 86.65  |
| 30.50                | 88.52 | 88.52  | 94.91 | 94.58  | 87.47 | 87.45  |
| 31.00                | 89.28 | 89.28  | 95.70 | 95.37  | 88.26 | 88.24  |